OUTLINE OF A COURSE IN GENERAL PHYSICS[1]

THE outline and suggestions for an elementary course in general physics are based upon the following assumptions:

1. The total time allotted is not less than thirty-six weeks; three periods of one hour each per week being devoted to the class work, and two periods per week of one and one-half to two hours each to be given to the laboratory work.

2. The number of pupils under an instructor at any one time is not to exceed thirty in the class work or twelve in the laboratory.

3. The laboratory periods are not necessarily devoted entirely to experimental work, a part of the time being given to general instruction, discussion of results, and solution of problems.

4. The prerequisites of the course are algebra and plane geometry.

OUTLINE OF SUBJECTS

NOTE.—Those subjects marked * should be illustrated by experiments in the class room. † are subjects for laboratory experiments, and § should be emphasized by problems.

1. Introduction.
   - (1) Classification of the phenomena or subjects.
   - *(2) Properties of matter.
2. Units and Standards.
   - (1) Distinction between unit and standard.
   - §*(2) The Common and Metric systems of units (mass and length).
   - §†(3) Relation between the fundamental units of both systems.
   - †(4) Methods of measuring length, including the vernier and micrometer screw
3. Pure Motion (Kinematics).
   - (1) Definitions of velocity and acceleration for constant and variable motion.
   - §(2) Uniform motion.

[1] This is the fourth article of the series prepared by the Departmental Examiners of the University of Chicago on the subjects required for admission to the University.

§ † * (3) Uniformly accelerated motion—development of formulæ and the special case of falling bodies.
(4) Circular Motion.
* (5) Simple Harmonic Motion.
† * (6) Composition and resolution of motion.

4. Relation between Force, Mass and Motion.
(1) Definitions, names and comparison of units.
* † § (2) General relation between force, mass and acceleration.
§ (3) Graphical representation of force.
* † § (4) Composition and resolution of force, including the case of circular motion.
§ (5) Gravitation--laws and cases.
* § (6) Center of mass and gravity.
† § (7) Momentum.
* § (8) Moment of a force.

5. Work and Energy.
* (1) Definition and illustrations of work, energy, power, potential and kinetic energy.
† § (2) The units of work, the relation between them, the connection between the work unit and the measurement of energy and power.
§ (3) The simple machines.
† (4) The balance—different forms.

6. The Pendulum.
* (1) Definition of simple and compound pendulum.
† § (2) Law of simple pendulum and its interpretation.
† (3) Application of the pendulum to the measure of time and "g."

7. Mechanics of Liquids.
§ * (1) Laws of fluid pressure and application.
(2) Compressibility.
* § (3) Principles of floating and immersed bodies.
§ † * (4) Density and specific gravity, including hydrometers.
* (5) Siphons and pumps.

8. Mechanics of Gases.
§ * (1) Atmospheric pressure in pounds, grams, dynes, c. c., and mm. of mercury.
* (2) Barometers, mercurial and aneroid.
† § * (3) Relation between pressure and volume of a gas.
§ * (4) Air pumps and air pump experiments.

9. Capillarity and Surface Tension.
* (1) Phenomena described and illustrated.
† § (2) Value of surface tension from tubes and by direct weighing
* (3) Applications.

10. Elasticity.
    *(1) Elasticity of volume and elasticity of form (rigidity).
    *(2) Elastic vibrations, transverse and longitudinal, compression and rarefaction.
    *(3) Coefficient of elasticity (Young's Modulus).
11. Sound.
    (1) Nature of sound, source, medium, receiver.
    §(2) Propagation of sound—formulæ interpreted.
    *(3) Reflection and refraction.
    *(4) Properties of sound.
    *(5) Musical scale and chords.
    *(6) Vibration of strings.
    *(7) Method of studying sound vibrations, graphical, and manometric flames.
    *(8) Resonance.
    *(9) Doeppler's principle.
    (10) Musical instruments.
12. Heat.
    †*(1) Temperature and instruments for measuring temperature.
    §†*(2) Specific heat, latent heat, and the laws of change of state and modifications, vapors, distillation.
    †*(3) Expansion and expansion coefficients.
    *(4) Conduction and convection, phenomena and laws.
    *§(5) Relation between work and heat, value of the mechanical equivalent, and description of experiments by which it was determined—the steam engine.
13. Radiation (Light and Heat).
    (1) Introduction to the ether and nature of radiation, classification of ether waves and methods of detection.
    §(2) Velocity and intensity of radiation.
    †§*(3) Reflection and refraction, lenses and mirrors, total reflection.
    *(4) Interference, diffraction, double refraction, and polarization, phenomena illustrated, and the simplest explained.
    †*(5) Dispersion, spectra, and spectroscope; how the spectroscope is used to determine substances in the laboratory, and the composition of distant bodies.
    *(6) Optical instruments, including the microscope, telescope. projection lantern, photographic camera, etc.
15. Electro-statics.
    *(1) Fundamental phenomena.
    *(2) Electricity and electrification, electric field conduction and dialectics.
    *(3) Electrification, a form of potential energy, how produced, how detected, kind.

§ * (4) Potential and difference of potential.
§ * (5) Capacity and condensers (defined).
* (6) Electro-static induction.
* (7) The electrophorus and simple electric machines.

16. Current Electricity.
* (1) Fundamental phenomena including field of force about a current.
† § * (2) Electro-motive force, resistance, conductivity, strength of current and Ohm's law—battery cells (simple).
* (3) Units — C. G. S. and practical units of current, resistance and E. M. F.
§ * (4) Joule's law and its applications.
† § * (5) Galvanometers and measuring instruments.
* (6) Electrolysis and electro deposition of metals — primary and secondary batteries treated further.

17. Magnetism and Electro-magnetism.
* (1) Definitions and phenomena of magnetism.
* (2) Force exerted by currents upon each other, and by currents upon magnets ; Ampere's theory of magnetism.
* (3) Effect of magnetic substances placed in the magnetic field about a current ; electro-magnets and application.

18. Electro-magnetic Induction.
* (1) Fundamental phenomena and laws.
* (2) Application including induction coils and phenomena, transformers, motors and dynamos, telephones, etc.

CLASS WORK

The class work should consist of recitations from the text-book, illustrations of the principal phenomena by the instructor, and the solution of problems by the student. The latter is of great importance, as the student often learns definitions and formulæ without appreciating their meaning. The class should occasionally be given written reviews or examinations. The questions used in such examinations should be carefully thought out and expressed in such a way that they become a test of the student's reasoning powers rather than a test of memory. The discipline derived from the clear and concise statement in writing of facts and the logical deductions therefrom is extremely valuable.

The written review brings out the relative progress of the

individuals and often shows that the class as a whole has failed to grasp some important fact. The papers are to be corrected and returned to the student, and it is well to call the attention of the class to the more common errors detected in the answers.

EXPERIMENTAL WORK

The results sought in experimental work may be classed as follows:

1. Methods of observation and the deduction of laws from the results of observation.

2. Emphasizing and fixing important laws and facts in the mind of the student.

3. Skill in manipulation or handling of apparatus.

4. The proper tabulation of experimental data and results.

The laboratory work should be carefully arranged and the value of each experiment considered in relation to each of the results sought. The number of experiments may vary from fifty to one hundred, depending upon the time allowed for each. A convenient method consists in arranging each experiment to occupy one complete laboratory period. This system permits of the most economical use of the apparatus and the student's time.

The experiments should be quantitative as far as possible and a degree of accuracy attainable such that the student may not lose faith in experimental work.

Great stress should be laid upon quality rather than quantity of work, and careful, accurate work encouraged.

Laboratory instruction.—While general instructions and the discussion of results may be taken up by the class as a whole, the greater part of the laboratory instruction is necessarily with the individual, and no instructor should have more students in the laboratory at one time than he can properly care for.

Students should be provided with a blank in duplicate, which contains a place for each observed or constant quantity needed in computing the result: these are filled out as the work progresses and at the end of the period one copy is handed to the instructor, the other, together with a sketch of the apparatus and method, form the student's laboratory notes.

Record of Experiments.—The final record of each experiment should be neatly written up from the student's laboratory notes as soon as possible after the experiment is performed and should state clearly, (*a*) the problem to be solved, (*b*) the method, (*c*) the observed and computed results. The sketches necessary should be confined to simple diagrams made with an ordinary ruling pen and compasses; shaded or perspective drawings are not to be permitted.

The tabulation of observed and computed results should be such that they may be readily compared. Whenever possible the results should be plotted in the form of curves.

The paper recommended is a medium weight linen ledger paper, cut in sheets 8 x 10½ inches, cross-ruled on both sides and punched with two holes one-half inch from the longer edge. The sheets are afterwards bound in covers punched to correspond. The ruling should be spaced six lines to the inch which is convenient for writing, tabulation, and curve plotting. Ten lines to the inch or five to the centimeter would be better but paper with lines closer than six to the inch is printed from plates, is expensive, and does not take ink well on the printed lines.

Laboratory manual.—Most of the text-books and laboratory manuals designed for an academic course in physics are too elementary in character. The recent text-books, however, are somewhat more advanced and contain many experiments suitable for the laboratory work. In many respects the combined text-book and laboratory manual is preferable. However, the instructor should exercise judgment in the selection of the exercises to be performed by the student in the laboratory; for example, the heating of a wire by an electric current is an experiment to be performed before the class by the instructor as an illustration, while the measurement of the power absorbed by an incandescent lamp is an excellent experiment for the laboratory.

EQUIPMENT

No school should undertake to give instruction in physics without a teacher well trained in experimental methods and a suitably equipped laboratory.

The instructor should also have at his disposal some simple but effective device for illustrating in the class room every important law or phenomena as it is taken up. A successful instructor will adapt many common and inexpensive articles of trade in devising class room illustrations and laboratory experiments. The list of apparatus for class demonstrations should, however, contain the following pieces of good quality :

A projecting lantern with vertical, spectroscope, and polarscope attachments, an adjustable window mirror for projecting with sunlight, an air pump, induction coil, large electro-magnet, and a source of current; six storage cells charged by a primary battery or from the street main form an admirable source of current for all class and laboratory work.

The laboratory equipment is also largely composed of inexpensive apparatus for definite experiments, but in addition it should contain a good balance with a sensibility of 0.5 m. g. and a capacity of 100 grams, a set of standard weights, a pendulum vibrating seconds (this need not be a clock, a free pendulum with mercury contact will answer), a standard of length, mercurial barometer, a good thermometer, pair of simple measuring microscopes, pair of telescopes of one inch aperture, spectrometer, galvanometer of high sensibility and a set of standard resistances.

No equipment is complete without a work room fitted with a small screw-cutting lathe and lathe tools, vise and bench tools, a few woodworking tools, and a supply of materials, such as sheet metals, wire, rods, hard rubber, wood, nails, screws, binding posts, etc. This part of the equipment is indispensable to the instructor in getting up class illustrations and laboratory apparatus. The class often contains a few students with considerable taste and skill in the use of tools and the instructor usually finds them willing assistants; to such students the construction of simple apparatus is a source of great benefit and delight.